

MONTHLY WEATHER REVIEW.

Editor: Prof. CLEVELAND ABBE. Assistant Editor: H. H. KIMBALL.

VOL. XXXI.

MAY, 1903.

No. 5

INTRODUCTION.

The MONTHLY WEATHER REVIEW for May, 1903, is based on data from about 3300 stations, classified as follows:

Weather Bureau stations, regular, telegraph and mail, 160; West Indian service, cable and mail, 8; River and Flood service, 52, river and rainfall, 177, rainfall only, 62; voluntary observers, domestic and foreign, 2565; total Weather Bureau Service, 2962; Canadian Meteorological Service, by telegraph and mail, 20, by mail only, 13; Meteorological Service of the Azores, by cable, 2; Meteorological Office, London, by cable, 8; Mexican Telegraph Company, by cable, 3; Army Post Hospital reports, 18; United States Life-Saving Service, 9; Southern Pacific Company, 96; Hawaiian Meteorological Service, 75; Jamaica Weather Service, 130; Costa Rican Meteorological Service, 25; The New Panama Canal Company, 5; Central Meteorological Observatory of Mexico, 20 station summaries, also printed daily bulletins and charts, based on simultaneous observations at about 40 stations; Mexican Federal Telegraph Service, printed daily charts, based on about 30 stations.

Special acknowledgment is made of the hearty cooperation of Prof. R. F. Stupart, Director of the Meteorological Service of the Dominion of Canada; Mr. Curtis J. Lyons, Territorial Meteorologist, Honolulu, H. I.; Señor Manuel E. Pastrana, Director of the Central Meteorological and Magnetic Observatory of Mexico; Camilo A. Gonzales, Director-General of Mexican Telegraphs; Capt. S. I. Kimball, Superintendent of the United States Life-Saving Service; Lieut. Commander W. H. H. Southerland, Hydrographer, United States Navy; H. Pittier, Director of the Physico-Geographic Institute, San José,

Costa Rica; Commandant Francisco S. Chaves, Director of the Meteorological Service of the Azores, Ponta Delgada, St. Michaels, Azores; W. M. Shaw, Esq., Secretary, Meteorological Office, London; Rev. Josef Algué, S. J., Director, Philippine Weather Service; and H. H. Cousins, Chemist, in charge of the Jamaica Weather Office.

Attention is called to the fact that the clocks and self-registers at regular Weather Bureau stations are all set to seventy-fifth meridian or eastern standard time, which is exactly five hours behind Greenwich time; as far as practicable, only this standard of time is used in the text of the REVIEW, since all Weather Bureau observations are required to be taken and recorded by it. The standards used by the public in the United States and Canada and by the voluntary observers are believed to conform generally to the modern international system of standard meridians, one hour apart, beginning with Greenwich. The Hawaiian standard meridian is $157^{\circ} 30'$, or $10^{\text{h}} 30^{\text{m}}$ west of Greenwich. The Costa Rican standard of time is that of San José, $0^{\text{h}} 36^{\text{m}} 13^{\text{s}}$ slower than seventy-fifth meridian time, corresponding to $5^{\text{h}} 36^{\text{m}}$ west of Greenwich. Records of miscellaneous phenomena that are reported occasionally in other standards of time by voluntary observers or newspaper correspondents are sometimes corrected to agree with the eastern standard; otherwise, the local standard is mentioned.

Barometric pressures, whether "station pressures" or "sea-level pressures," are now reduced to standard gravity, so that they express pressure in a standard system of absolute measures.

FORECASTS AND WARNINGS.

By Prof. E. B. GARRIOTT, in charge of Forecast Division.

In the United States the weather of May, 1903, presented strikingly abnormal features. New England, and the greater part of New York, received practically no rain from the 4th until the closing days of the month. In the Middle Atlantic States an unbroken period of dry weather extended from the 4th to the 22d. Excessive rains fell in the South Atlantic States from the 6th to the 15th. In the Ohio Valley, Tennessee, the Gulf States, and the greater part of the Lake region the rainfall was abundant. In the Pacific coast States the month was unusually dry. During the last decade of the month, and more particularly from the 24th to the 27th, a succession of severe local storms, some of which developed into tornadoes, visited the States of the lower Missouri and upper Mississippi valleys. From the 19th until the close of the month excessive rains over the water sheds of the lower Missouri and upper Mississippi rivers produced floods that in the lower Missouri Valley were the most formidable that have occurred since 1844.

THE SEVERE LOCAL STORMS OF MAY 24 TO 27 IN THE MIDDLE-WESTERN STATES.

Excessive atmospheric heat and moisture are recognized factors in the production of severe local storms. The origin of storms of this character depends, therefore, upon general atmospheric conditions which promote unseasonable warmth and abnormally high humidity in the regions in which they

occur. These conditions usually develop slowly and may be detected, and even anticipated, by means of charted reports of daily meteorological observations that have been simultaneously taken over a large area surrounding the storm threatened district.

As the atmosphere receives its moisture from the water surfaces of the earth it follows that excessive humidity in the central valleys of the United States must be due principally to moisture laden air from the Atlantic or the Gulf of Mexico, and it is also apparent that these masses of air from southern latitudes possess temperatures that are higher than the average temperature of the more northern districts over which they are carried. The mechanical processes that are employed in producing a flow of warm, moist southerly winds over the interior districts of the United States obey the laws of cyclonic and anticyclonic wind circulation, and are illustrated on the daily weather maps.

General barometric conditions favorable for a persistent and strong flow of southerly winds over the Mississippi and lower Missouri valleys appeared May 15. From that date until the 27th the barometer continued low over the Rocky Mountain region and the Missouri Valley and high over the Atlantic and Pacific coast districts. During the 27th an area of low barometric pressure passed northeastward to the upper Lake region, and after that date a barometric disturbance drifted slowly eastward from the middle-eastern Rocky Mountain slope to the

middle Mississippi Valley. Rain set in over the Missouri Valley and the Northwest the night of the 16th, and continued almost uninterruptedly over the water sheds of the Missouri and upper Mississippi rivers until the close of the month. During the entire period from the 16th to the 27th the wind continued southerly and the temperature abnormally high in the Mississippi and lower Missouri valleys. Following the passage of the low area to the upper Lakes on the 27th, and the subsequent eastward movement of the low area over Kansas and Missouri the temperature fell in the lower Missouri and upper Mississippi valleys, and temperature conditions favorable for the development of severe local storms were not present in those districts during the remainder of the month.

The general weather conditions that prevailed over the United States from May 20 to 31 are shown on charts Nos. XI-XXII herewith. Rains set in over the Missouri Valley on the 16th, but the morning temperatures in that section did not favor the development of severe local storms until the 22d, when the temperature line of 70° looped northward over the Mississippi and lower Missouri valleys to the southern border of Iowa. Within the area bounded by this line thunderstorms occurred on the 22d and 23d.

The first storm of a tornadic character reported occurred in southeastern Nebraska during the afternoon of the 24th, when several persons were killed and property was destroyed in Clay, Franklin, Kearney, and Adams counties. On the 25th severe local storms, some of which were doubtless tornadoes, occurred in eastern Kansas, eastern Nebraska, and southern Iowa. In Kansas tornadoes that were attended by a number of fatalities were reported in Miami and Shawnee counties. In Nebraska the areas of maximum storm intensity appeared to be in Clay and Adams counties. In Iowa the storm belt covered the southern half of the State. On the 26th the region visited by local storms of a severer character embraced southeastern Nebraska, southwestern Iowa, and extreme northwestern Missouri. On the 28th severe and destructive thunderstorms occurred in northern Illinois, northern Indiana, and northwestern Ohio.

The devastating floods occurring over a great part of the storm visited district during the closing days of the month were, in part, coincident with the local storms under discussion, and it is impossible, therefore, to at present determine which of the agents of destruction was responsible for many of the losses reported. It is known, however, that reports of some of the storms were exaggerated, and that in instances so-called tornadoes were thunderstorms or wind squalls of unusual violence.

The tendency to exaggeration in reports of meteorological phenomena of a violent character is common and natural. In the case of local storms the destroying power of the severest thunderstorm or wind squall has about the relation to the destroying power of a tornado that the work that can be done in a specified time by a hand sickle has to the work that can be accomplished by a power reaper. The thunderstorm wrecks only frail structures; the true tornado dislodges solid masonry and mows a path through forests of sturdy trees as clean cut as that made by a reaper through a field of grain.

Estimates made in connection with the local storms of May 24 to 27 place the number of killed at about fifty, the number of injured at about sixty, and the property loss in the tens of thousands. The destruction of life and property was confined principally to eastern Nebraska and southern Iowa.

THE MAY, 1903, FLOODS IN THE LOWER MISSOURI AND UPPER MISSISSIPPI VALLEYS.

The floods in the lower Missouri and upper Mississippi valleys were due almost entirely to heavy rains in that region, snow water from the headwaters of the Missouri contributing but slightly to the flood wave. The principal streams involved

in the flood were the Missouri, Kansas or Kaw, Big Blue, Des Moines, and Mississippi, and the principal States affected were Kansas, Nebraska, Missouri, and Iowa. The main flood came from the Kansas River, which flows eastward through Kansas and joins the Missouri River at Kansas City. The loss by flood in the State of Kansas has been estimated at \$12,000,000, mostly to crops and railroads, and in North Topeka alone a number of persons were drowned and thousands were rendered homeless by fire and flood.

At Kansas City the river passed the danger line, 21 feet, on the 27th, and reached a height of 27.5 feet on the morning of the 31st. The crest of the flood was reached on June 1, when a stage of 35 feet was shown on the gage. This was 14 feet above the danger line, and but 2.0 feet below the recorded high water mark of June 20, 1844. The loss by flood at Kansas City is placed in the neighborhood of \$10,000,000. Beginning May 26 the Weather Bureau issued daily advices regarding the heavy rains and the probable effect they would have on the rivers in that vicinity.

The rainfalls of the last sixteen days of May at stations between the Mississippi River and the Rocky Mountains are indicated in the table herewith. The period of heaviest rainfalls extended from the 22d to the 31st. Among the greater amounts of rainfall reported for this 10-day period are: 8.96 inches at Des Moines, Iowa; 9.15 inches at Concordia, Kans.; 4.88 inches at Davenport, Iowa; 4.27 inches at Omaha, Nebr.; 3.61 inches at Dubuque, Iowa; 2.46 inches at Keokuk, Iowa; and 2.87 inches at Wichita, Kans. Heavy rains and destructive floods also occurred during this period in Oklahoma and Indian Territories. At Oklahoma 8.77 inches of rain fell during the last ten days of May.

June opened with the flood wave moving down the Missouri River below Kansas City, and the Mississippi River above the danger line from Keokuk to the mouth of the Missouri River. On June 1 warnings were issued that the danger line at St. Louis, 30 feet, would be reached within thirty-six hours and a stage of 34 feet attained within four days. The danger line was reached at St. Louis on the 2d, the Mississippi was above the danger line as far north as Dubuque, and between Keokuk and Hannibal was 3.5 to 4.5 feet above. Daily warnings were continued from three to four days in advance along the flooded districts of the Mississippi, and on the 6th interests in and about St. Louis were warned to prepare for a 38-foot stage. This stage was reached four days later, on June 10, and was the maximum height reached at St. Louis.

On June 5 the levee broke just below Louisiana, Mo. This levee inclosed a fertile farming region containing more than 100,000 acres, and a population of probably 10,000. The levee had not been overflowed since 1888, and the damage by the break of the present year has been estimated in the millions of dollars.

The stage at St. Louis on the 10th was 0.5 higher than the stage reached on May 19, 1858, and 3.4 below the recorded high water mark of June 28, 1844.

The damage and loss of life caused by the floods of June, 1903, along the upper Mississippi River, and along the Missouri River east of Kansas City, can not now be approximated. Conservative estimates place the damage to property and crops at many millions of dollars. Throughout the entire flood visited area all points that could be reached by telegraph, telephone, or mail were supplied with warnings accurately forecasting, from three to four days in advance, stages that would be recorded on river gages at Weather Bureau stations, and as a result of these warnings thousands of persons were enabled to remove themselves and their portable property to places of safety.

Detailed descriptions of the floods will be found under the heading "Rivers and floods," and will be published later.

Low barometric pressure prevailed over the southern por-

Daily rainfall at Weather Bureau stations between the Mississippi River and the Rocky Mountains, May 16-31, 1903.

Stations.	16.	17.	18.	19.	20.	21.	22.	23.	24.	25.	26.	27.	28.	29.	30.	31.	Total.
Williston, N. Dak.	0.16	0.08	0.34	T.	T.	0.94	1.49	0.12	0.02		0.08		0.60	0.04			3.87
Bismarck, N. Dak.		T.	0.86	T.		0.47	1.06				0.20					0.50	3.09
Pierre, S. Dak.		0.26				0.14	0.62		0.19		0.04			0.46	T.		1.71
Rapid City, S. Dak.	0.02	0.14	0.30	0.16		0.14	0.18		T.	0.02			T.	0.12		0.16	1.24
Huron, S. Dak.				T.		0.16	0.50	0.34	0.24	0.08	0.24	0.01			0.10	0.03	1.57
Yankton, S. Dak.				0.03	T.	0.39	0.76	0.63	1.00		0.39	0.39	0.43	0.40			4.55
Miles City, Mont.		0.10	0.22	0.02		0.26	0.16	0.06					0.22				1.04
Havre, Mont.	0.02	0.96	0.44	0.64		0.06	0.88	0.28	0.06			0.04	0.02				3.40
Helena, Mont.	0.50	0.40	0.28	0.01		T.	T.	0.30		0.04		0.04					1.57
St. Paul, Minn.		T.		0.10			0.01	0.64	T.	0.62	1.04	0.24					2.65
Moorhead, Minn.		0.04	0.30	0.60			0.42	1.50									3.10
Valentine, Nebr.						0.26	0.24	T.	0.10	0.04	0.50			0.32	0.02		1.48
North Platte, Nebr.	T.					0.18	0.02		0.02	0.08	0.18		0.01	0.43	0.06		0.98
Lincoln, Nebr.		0.07	T.	0.24		0.56	0.79	0.28		1.37	1.03	0.43	0.15	1.94	1.13	0.10	8.09
Omaha, Nebr.		0.16		0.04	0.10	0.64	0.80	0.01		0.95	0.93	0.56	T.	0.52	0.40	0.10	5.21
Concordia, Kans.	0.30	0.14	0.78	0.04		0.18	1.10	0.94		0.16	0.96		1.64	3.68	0.25	0.42	10.59
Topeka, Kans.	T.			0.05		0.50	0.04	0.64	0.35	0.22	0.21	0.28	0.24	1.71	0.26	0.91	5.41
Wichita, Kans.	0.01		0.98	0.10		2.24	0.04	1.29	T.		0.22		0.22	0.82	0.02	0.26	6.17
Dodge, Kans.	0.14	0.10			0.10	0.58	0.06				0.30	0.26	0.28	0.03	0.04		1.89
Denver, Colo.	T.	T.	0.01			T.	T.	T.		0.01	T.		0.01	0.03		0.28	0.34
Pueblo, Colo.											0.06		0.22	T.			0.28
Cheyenne, Wyo.	0.10	0.06	0.10			T.	0.01		T.		T.		0.12	T.			0.39
Lander, Wyo.		0.62	T.			0.06	0.18		0.48	T.		T.	0.01	0.03			1.38
Oklahoma, Okla.	0.58	T.	.01	T.		0.02	1.25	T.	4.06		T.		0.18	3.26	0.02	T.	9.38
Fort Worth, Tex.	T.	0.01				T.		T.	T.		T.		0.68	0.46	T.		1.15
Abilene, Tex.	T.	0.10				T.						T.					0.10
Amarillo, Tex.	T.				T.	0.54											0.54
Palestine, Tex.		0.04		T.								0.06	0.05	0.49	0.18		0.82
Taylor, Tex.		0.05		0.10	T.	T.	T.	T.	T.			T.	0.02	0.02	0.30		0.49
San Antonio, Tex.		0.55	0.01	0.02	T.	T.	0.01	T.				T.			0.01		0.60
Dubuque, Iowa.		0.08	T.	T.	0.01	0.06	0.50	0.02		0.10	1.40	1.11	0.02	T.	0.34	0.12	3.76
Davenport, Iowa.			T.	T.		0.48	0.08	0.20	0.05	0.08	0.87	0.42	0.38	0.32	2.02	0.46	5.36
Des Moines, Iowa.		0.30	T.	0.04	0.02	0.06	1.38	0.12		0.18	2.08	1.38	0.06	0.94	2.52	0.30	9.38
Keokuk, Iowa.		T.	0.06	T.		0.76	0.04	0.06	1.40	0.52		0.06		T.	T.	0.38	3.28
Sioux City, Iowa.		0.02	0.72	1.08		0.88	0.24	0.02	0.01	0.47				2.27	0.42	0.08	6.21
Kansas City, Mo.		0.02		0.06	T.	0.70	0.34	0.74	0.26	0.22	T.	0.76	0.01	0.23	0.68	1.08	5.10
St. Louis, Mo.			0.16	0.04	0.40	0.06			T.	0.01	T.	0.12		0.40	T.	0.42	1.61
Springfield, Mo.	T.	0.04	0.02	0.70	1.06	0.35			0.06		T.	T.	0.20	0.80	1.54	1.66	6.43
Hannibal, Mo.		T.	0.17	0.02		0.49		0.04	1.93	0.06	T.	0.04	0.28	0.32	1.61	3.96	
Fort Smith, Ark.	T.	0.03	T.	1.36	T.		T.				T.	0.22	0.02	1.96	0.12	0.44	4.15
Little Rock, Ark.	T.	T.	T.	0.54	T.							T.	1.14	0.68	0.91	T.	3.27
Shreveport, La.		T.	T.	T.								T.	0.02		T.	0.06	0.08

tion of the British Isles during the first decade of the month, and from the 13th to the 16th and 20th to the 24th barometric disturbances were central near the north of Scotland. From the 25th to the 27th the barometer was high over the British Isles.

Storms of marked severity were not reported on the North Atlantic Ocean nor on the Atlantic and Gulf coasts, the Great Lakes, and the north Pacific coast of the United States. On the California coast high northwest winds prevailed during the latter half of the month.

BOSTON FORECAST DISTRICT.

Except the severe drought, which prevailed throughout the month in all sections of the district, the weather of the month was uneventful. One storm warning was ordered on the 27th, which was fully justified along the middle and northern coast, and no storms or high winds occurred for which warnings were not issued.—*J. W. Smith, Forecast Official.*

NEW ORLEANS FORECAST DISTRICT.

The month opened unseasonably cold, with the lowest temperatures on record during the first decade of May in some parts of the district. The forecasts issued for the above conditions on the last day of April were discussed in the report for that month. The frost on the 1st and 2d materially injured cotton in some places. Truck gardens were successfully protected. Storm warnings were issued for parts of the coast on the 10th, 16th, and 28th. Brisk to high winds occurred during the displays. As a whole, the month was unusually mild.

The river continued falling slowly during the month; it was above danger line at New Orleans until the 22d and at Melville, La., at the close of the month. As the water recedes from the overflowed districts, data are being gathered relative to the extent of the overflow and damage resulting therefrom.

Efforts to close the crevasse at Hymelia, 40 miles above New Orleans, proved unsuccessful, and the work has been abandoned. The water is receding very slowly from the over-

flowed district in the vicinity of this crevasse. Full report on the high water is being prepared as rapidly as possible.—*I. M. Cline, Forecast Official.*

CHICAGO FORECAST DISTRICT.

The Lakes were unusually free from severe storms; the only storm of consequence occurred near the end of the month, for which warnings were sent out well in advance. No casualties of note, due to stress of weather, were reported.—*H. J. Cox, Professor of Meteorology.*

SAN FRANCISCO FORECAST DISTRICT.

The month was, as a whole, exceptionally dry. At San Francisco the month was the driest since 1873, and in general this is true for a large portion of the State. Taken in connection with the dry period during the latter half of April, the result was an unfavorable period for the successful maturing of crops. An interesting question also arises as to whether a progressive easterly movement of this dry period can be traced from the Pacific coast to the Rocky Mountain region and, possibly, to the great central valley. The accompanying table of total air movements shows the extended duration of high winds along the California coast. At Point Reyes Light, Cal., for a period of nine consecutive days, the total air movement recorded was 11,223 miles, or an average hourly movement exceeding 50 miles. (See the special report on a subsequent page.)

The beginning of the month was marked by a distribution of pressure similar to that shown on Chart IV, Sea Level Pressure, MONTHLY WEATHER REVIEW, May, 1902. On May 12, 1903, a depression of moderate depth passed over Washington, Vancouver Island, and British Columbia, and for a brief period the winds on the Pacific coast were from the southeast. There was a quick reversion, however, to the type of pressure distribution first described, and for the balance of the month high northwest winds prevailed with little cessation. The total air movements for the month are as follows: